

J. Lightweight Closure Panels Project

Principal Investigator: Gene Cowie

Auto/Steel Partnership

2000 Town Center, Suite 320, Southfield, MI 48075-1123

(248) 945-4779; fax: (248) 356-8511; e-mail: gcowie@a-sp.org

Chairman: Paul Geck

Ford Motor Company, Scientific Research Laboratory

2101 Village Road, Dearborn, MI 48124

(313) 323-0014; fax: (313) 390-0514; e-mail: pgeck@ford.com

Technology Area Development Manager: Joseph A. Carpenter

(202) 586-1022; fax: (202) 586-1600; e-mail: joseph.carpenter@ee.doe.gov

Field Technical Manager: Philip S. Sklad

(865) 574-5069; fax: (865) 576-4963; e-mail: skladps@ornl.gov

Contractor: U.S. Automotive Materials Partnership

Contract No.: FC26-02OR22910

Objectives

- Reduce the mass of a vehicle door outer panel by 20% at a maximum cost increase of \$0.70/lb (\$1.55/kg) of mass saved.
- Compare the results of computer-aided engineering (CAE) formability studies with the results of stamping try-outs.
- Develop a “tool kit” to guide in the design of door and body panels, which currently use mild steels, to use steels that have higher strength but lower formability.

Approach

- Select several grades of steel that could potentially meet the objectives.
- Run CAE studies on the base material and the selected grades in several thicknesses. The CAE tests include formability and performance criteria such as stiffness and dent resistance.
- Build soft tooling and perform stamping trial runs.
- Assemble the outer panels to inner panel assemblies for stiffness and dent testing for those grades and thicknesses that produce satisfactory panels.

Accomplishments

- Completed CAE simulations and selected two grades of steel: BH250 (bake hardenable) and DP500 (dual phase).
- Built “soft” (Kirk site, zinc-based alloy) tooling and an assembly fixture (hem buck).
- Performed stamping trials and compared the results with the CAE analyses.
- Identified acceptable panels that are being assembled to inner panel assemblies for subsequent painting and dent testing.

Future Direction

No additional work is scheduled for this project. A final report documenting and summarizing the results of all experiments related to the use of specific grades and gages of door outer materials, including various surface coatings, will be complete by the December 31, 2004. Reporting will be completed by April 1, 2005.

Introduction

In 2000, the Auto/Steel Partnership started the Lightweight Closures Project team with the goal of reducing the door-in-white mass by 25%, while incurring a cost penalty of less than a \$0.70/lb of mass reduced (\$1.55/kg) and retaining steel as the primary structural material. The new Jeep Liberty front door, which at that time was still in the preproduction phase, was chosen as the baseline. It was chosen because (1) it represented the state of the art in that it used a laser-welded blank for the inner panel, (2) all of the component designs were well-optimized, (3) the overall door architecture was fairly conventional when compared with other candidate doors in the industry, and (4) it was for a sport utility vehicle where mass reductions are particularly desirable.

The two largest mass contributors to the structure of an automotive door are the inner panel (45%) and the outer panel (33%). Significant efforts by the automotive industry to reduce the mass of the door inner panel have led to a de-facto standard tailor-welded blank (TWB). This construction eliminates or minimizes the need for reinforcements at the front of the door by substantially increasing the thickness of the leading edge of the door inner while the remainder of the door inner panel remains at traditional gages.

Most of the initial effort was focused on innovative changes to the door inner architecture. This effort led to the conclusion that, while door inner mass reductions could be achieved in the range of 15 to 20%, the reductions were accompanied by cost increases in the \$2.00/lb (\$4.40/kg) range.

Preliminary calculations on the door outer panel indicated a potential to reduce its mass by 20% while incurring no additional cost by using advanced high-strength steels, with associated latest generation CAE tools and stamping technology. Therefore the project team redirected its efforts to address the outer panel. The team selected seven of the most capable body design and manufacturing companies in southeastern Michigan to submit

quotations. The project team reviewed the proposals based on technical competency, qualifications of key personnel, demonstrated experience, and understanding of the project requirements, qualifications of named subcontractors, and price. Oxford Automotive, which had participated in the door inner panel study, was selected to perform the work.

Discussion

The Lightweight Closure Panels Project Team was selected to include members of auto producers and steel producers with extensive experience in forming sheet steel body panels. This membership enabled the team to narrow the selection of steel grades for the outer panel study to two: BH250 (bake hardenable) and DP500 (dual phase). Both grades have been developed to give strengths significantly higher than mild steels, which are commonly used in body panels, while retaining a high degree of formability. Both grades had been laboratory tested extensively so that all of the material properties essential to forming operations were documented.

The existing production panel is being made from mild steel with a thickness of 0.74 mm (0.0291 in.). Three thicknesses were selected for the test materials: 0.7 mm (0.0275 in.), 0.65 mm (0.0255 in.) and 0.6 mm (0.0235 in.). Several different types of corrosion-resistant surface treatment were analyzed, because surface treatment affects formability.

The computer-aided engineering (CAE) forming analyses began with the baseline material to confirm the parameters of the CAE process. When the higher strength materials were run, several areas of the panel with “crisp” styling features (sharp radii) were identified as potential trouble spots. The major problems occurred at the beltline (immediately below the window opening) and mirror pocket (slight recess into which the outside mirror fits). To relieve these problems, the team agreed on two minor changes: an increase in the bending radius on

the beltline feature and a reduction in the depth of the mirror pocket. The beltline modification constituted a minor styling change. The mirror pocket could result in no styling change by slightly modifying the mirror.

Numerous tests were run and discussed by the team at regular meetings. When the simulations indicated that there was a reasonable chance for several of the test materials to be formed, soft tools (Kirksite, zinc alloy) were built, and the work was transferred to a subcontractor who specializes in die try-out. This company's expertise enabled them to identify problem areas on the panels and recommend appropriate modifications to the stamping process to correct the problems.

The panels were visually inspected by all involved parties and checked for springback. Those that were considered acceptable were set aside for assembly, painting, and display. A typical panel that was successfully formed is shown in Figure 1.

When panels were not successfully formed in the baseline design, the die was successively modified to the design variations agreed upon by the project team and rerun.

In addition to the soft tooling, a hem buck was prepared to assemble the outer panel to production inner panels, which were an in-kind contribution by DaimlerChrysler Corporation. The acceptable panels were subsequently assembled to form a



Figure 1. Typical door outer panel before trimming.

complete door structure (minus glass, window regulator, trim, etc). The assemblies are scheduled for painting and dent testing, which will conclude the build-and-test portion of the program.

Conclusions

- Two grades of steel, BH250 (bake hardenable) and DP500 (dual phase) can be successfully formed into door outer panels in gauges less than 0.74 mm (0.029 in.).
- CAE programs can be used as first-order analysis tools to guide the selection of sheet steel grades (material, thickness, and surface coating) to be formed in stamping dies.

